

# Dealing with Project Uncertainties

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# DEALING WITH PROJECT UNCERTAINTIES

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One of the most challenging aspects of managing projects today is that of including uncertainties in our estimates. Specifically, uncertainties with task durations, task efforts, and task costs.

## DETERMINISTIC ESTIMATING

Consider a project manager who asks a software engineer how long it will take her to do the necessary software debugging on her program. In her mind she may be thinking anywhere from 14 days to 35 days, but since the project manager is asking for a single estimate, she frustratingly says, “25 days.” In taking this approach the project manager has failed to take into account the uncertainties related to the software debugging task. He has mistakenly used a single-point estimate, referred to as a *deterministic estimate*. If deterministic estimates are made throughout the entire project schedule, the project completion date will be inaccurate and overly optimistic, resulting in misplaced expectations. Everyone will assume the estimated project completion date can be met with a high degree of confidence. In actuality, the chances of meeting the estimated project completion date will be 50% or less. The same can occur when estimating task efforts (labor hours), and task costs. Inaccurate estimates result when using the deterministic approach.

## STOCHASTIC ESTIMATING

In order for uncertainties to be included in the project estimates it is necessary to take into account an optimistic estimate (o), a pessimistic estimate (p), and a most-likely estimate (m). This approach is referred to as *stochastic*, or *statistical* estimating, and is the correct technique to use when developing what is known today as a PERT (Program Review and Evaluation Technique)<sup>1</sup> network for project scheduling.

Using this approach the project manager asks the software engineer for an optimistic estimate (o), a pessimistic estimate (p), and a most-likely estimate (m). She now provides him with the three needed estimates of 14 days, 25 days, and 35 days. Using these three estimates, and three from all other critical path activities, the project manager can now calculate the project’s true duration at a desired level of confidence, such as 90%.

This is accomplished by using the equation below:

$$D = \sum T_e + Z\sqrt{\sum \sigma^2}$$

Where:

$\sum T_e$  = the sum of all critical path expected times.

$\sum \sigma^2$  = the sum of all critical path variances.

$Z$  = the number of standard deviations of a normal distribution (the standard normal deviate) taken from Table 2.

$$T_e = \frac{o + 4m + p}{6}$$

$$\text{Variance} = \sigma^2 = \left( \frac{p - o}{6} \right)^2$$

These equations are based on a normal distribution (Figure 1) which is deemed to be the best model for making these types of estimates. Using project estimates (task durations, task hours, or task costs), such as those in Table 1, the estimated value at a given probability can be made as shown below:

$$D = \sum T_e + Z\sqrt{\sum \sigma^2}$$

$$D = 463 + 1.2810\sqrt{168.4}$$

$$D = 480$$

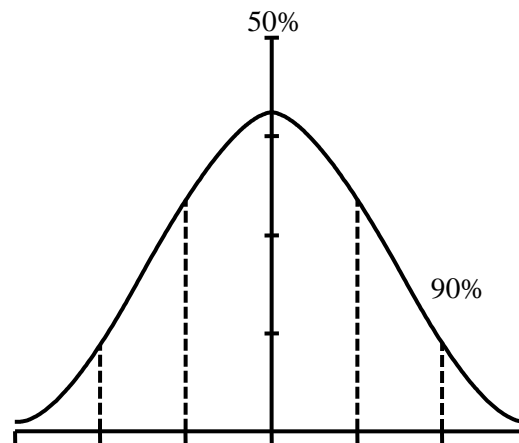


Figure 1 - Normal Distribution

It can be noted that the sum of the most-likely estimates may not always be equal to the sum of the expected times ( $\sum T_e$ ). See Table 1. This is because the most-likely estimate may not always be at the mid-point between the pessimistic and optimistic estimates. Regardless of the shape formed by the data values of the estimates, the shape of the values making up the sampling distribution of the expected times will approach a normal distribution based on the *central limit theorem*, if the sampling size is sufficiently large (usually 30 or greater). When the sampling size is less than 30, and the Central Limit Theorem cannot be invoked, a t-distribution must be used.<sup>2</sup>

Table 1- Project Estimates

Sample No.	Optimistic (o)	Most Likely (m)	Pessimistic (p)	Expected Value ( $T_e$ )	Std Dev. ( $\sigma$ )	Variance ( $\sigma^2$ )
1	14	25	35	25	3.5	12.3
2	20	20	28	21	1.3	1.8
3	5	8	9	8	0.7	0.4
4	7	10	14	10	1.2	1.4
5	2	5	7	5	0.8	0.7
6	8	12	15	12	1.2	1.4
7	2	5	8	5	1.0	1.0
8	10	15	22	15	2.0	4.0
9	6	8	9	8	0.5	0.3
10	4	7	9	7	0.8	0.7
11	10	12	15	12	0.8	0.7
12	8	16	18	15	1.7	2.8
13	5	8	10	8	0.8	0.7
14	10	15	22	15	2.0	4.0
15	6	8	9	8	0.5	0.3
16	4	7	9	7	0.8	0.7
17	10	12	15	12	0.8	0.7
18	8	16	18	15	1.7	2.8
19	5	8	10	8	0.8	0.7
20	10	18	28	18	3.0	9.0
21	4	4	4	4	0.0	0.0
22	25	35	50	36	4.2	17.4
23	4	16	38	18	5.7	32.1
24	2	9	15	9	2.2	4.7
25	4	7	9	7	0.8	0.7
26	10	12	15	12	0.8	0.7
27	8	16	18	15	1.7	2.8
28	7	10	14	10	1.2	1.4
29	2	5	7	5	0.8	0.7

30	8	12	15	12	1.2	1.4
31	2	5	8	5	1.0	1.0
32	10	15	22	15	2.0	4.0
33	25	35	50	36	4.2	17.4
34	4	16	38	18	5.7	32.1
35	2	9	15	9	2.2	4.7
36	4	7	9	7	0.8	0.7
37	10	12	15	12	0.8	0.7
460			Total ( $\Sigma$ )	463	61.2	168.4

## **SCHEDULE ESTIMATING VS. DURATION/COST ESTIMATING**

When estimating the project's true duration it will be necessary to use only the critical-path tasks. However, when estimating the project's total cost, or total effort (labor hours), it will be necessary to consider all project tasks.

### **A WORD OF CAUTION**

The three estimates provided by the software engineer were based on her knowledge, experience and judgment, and are referred to as subjective probability estimates. It therefore stands to reason that the accuracy of a stochastic estimate will be dependent upon a well-founded estimate for the three cases (o,m, and p). If inaccurate estimates are provided, due to inexperience, lack of knowledge, or simply a sloppy estimate, an inaccurate final estimate will result. In other words, garbage in, garbage out. It is imperative that the project manager make every effort to obtain the best possible estimates when dealing with uncertainties.

Table 2 – Cumulative Probabilities of a Normal Distribution<sup>3</sup>

Z	Probability
0.000	50
0.025	51
0.050	52
0.075	53
0.100	54
0.125	55
0.150	56
0.175	57
0.200	58
0.227	59
0.254	60
0.278	61
0.309	62
0.332	63
0.358	64
0.387	65
0.413	66
0.440	67
0.468	68
0.498	69
0.525	70
0.553	71
0.583	72
0.613	73
0.643	74
0.675	75
0.707	76
0.740	77
0.772	78
0.808	79
0.842	80
0.878	81
0.917	82
0.954	83
0.994	84
1.038	85
1.081	86
1.128	87
1.175	88
1.228	89
1.281	90
1.341	91
1.401	92
1.478	93
1.558	94
1.648	95
1.751	96
1.881	97
2.054	98
2.330	99
3.49	99.98

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1 Program Review and Evaluation Technique PERT (Program Evaluation and Review Technique) is an event-oriented network analysis technique used to estimate project duration when there is a high degree of uncertainty with individual activity estimates.

2 “The Essentials of Business Statistics I,” by Louise J. Clark. Research and Education Association, 1991. ISBN 0-87891-841-8.

3 Values for Z were taken from “Project Management, A Managerial Approach,” Jack R. Meredith and Samuel J. Mantel, Jr., John Wiley & Sons, NY, 1995.

## **WHERE TO GET MORE INFORMATION**

“The Essentials of Business Statistics I,” by Louise J. Clark. Research and Education Association, 1991. ISBN 0-87891-841-8.

“Project Management, A Managerial Approach,” Jack R. Meredith and Samuel J. Mantel, Jr., John Wiley & Sons, NY, 1995. ISBN 0-471-29829-8.

“Basic Business Statistics – Concepts and Applications,” Mark L. Berenson and David Levine, Prentice Hall 1999. ISBN 0-13-795618-5.

“Statistics for Business and Economics,” James T. McClave, P. George Benson, and Terry Sincich, Prentice Hall 2001. ISBN 0-13-027293-0.